



# IPP Seed Fund Success

**NASA's Innovative Partnerships Program**

April 2009







# IPPoffice

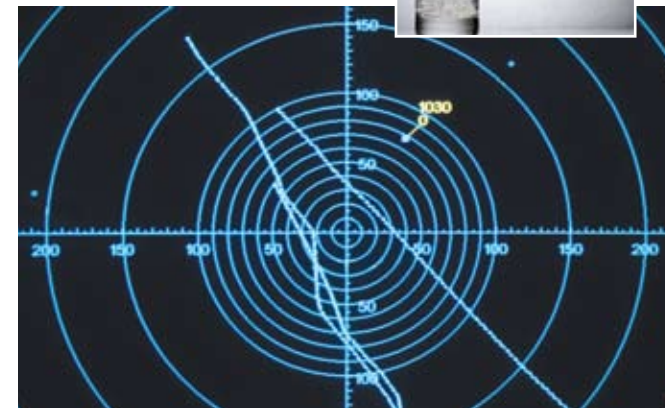
## Impact of the Innovative Partnerships Program and its Seed Fund

NASA's Innovative Partnerships Program (IPP) strives to facilitate partnerships with the U.S. private sector and leverage private resources to produce technologies needed for NASA missions. IPP's Seed Fund helps NASA realize its mission capability goals by providing leveraged funding to establish cost-shared, joint-development collaborations.

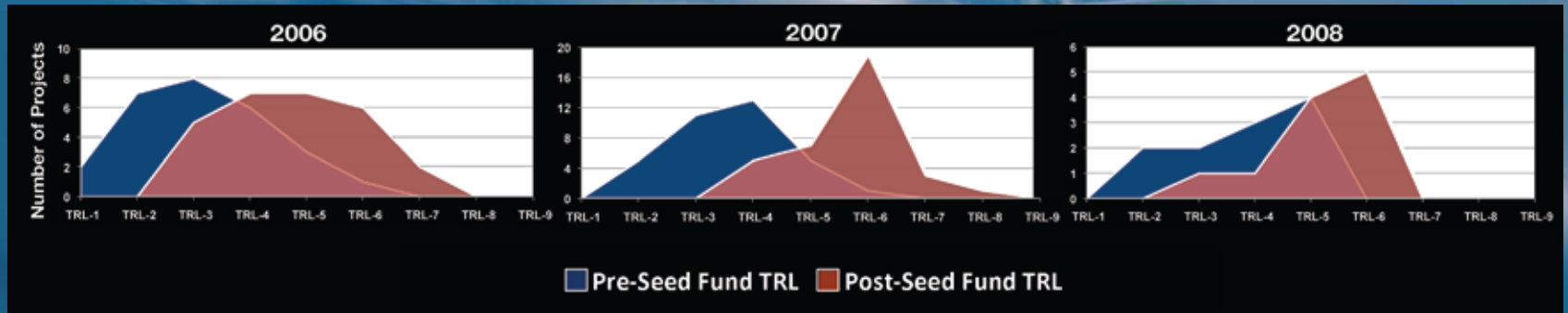
The IPP Seed Fund seeks to enhance NASA's ability to access a wide range of technology solutions, facilitate cost avoidance, accelerate technology development, and provide a larger pool of qualified commercial providers. Its funding enables numerous partnerships and development efforts. The program encourages pooling of resources and expertise from a variety of sources, encompassing non-NASA partners and all NASA centers.

*For more information on the  
IPP Seed Fund please visit:*

*[http://ipp.nasa.gov/ti\\_seed\\_fund.htm](http://ipp.nasa.gov/ti_seed_fund.htm)*



## IPP Seed Funding Advanced Technology Readiness Levels



# TRLshift

## Success story

### Furthering Technology for Missions

Monitoring the progress of technology development helps IPP meet its Seed Fund objectives. Technology Readiness Level (TRL) is the measure NASA uses to assess the maturity of evolving technologies. The scale, ranging from one to nine, indicates each stage in the development process, from observation of basic principles to final product operation. Starting and ending TRL levels are recorded for each Seed Fund project to assess the impact of project funding on its technology advancement.

The charts above highlight the technology advancements that have occurred through the IPP Seed funding and its partnerships.



GSFC researcher Peter Shirron works on his continuous adiabatic demagnetization refrigerator (ADR)

### *Development of a CADR and Integrated Control Electronics (GSFC 2006)*

NASA's Goddard Space Flight Center (GSFC), Lake Shore Cryotronics, and Lockheed Martin are advancing adiabatic demagnetization refrigerator (ADR) technology to be flown on two missions selected by NASA Headquarters for its Explorer Program Mission of Opportunity, with more than \$44 million of funding.

This achievement crowns over 10 years of ADR technology development and collaboration with Goddard's IPP Office for incremental funding sources and partnerships to maintain research progress.

*Technology infused into one of NASA's next Explorer Program Mission of Opportunity investigations, with funding over \$44 million*



# Leveraging

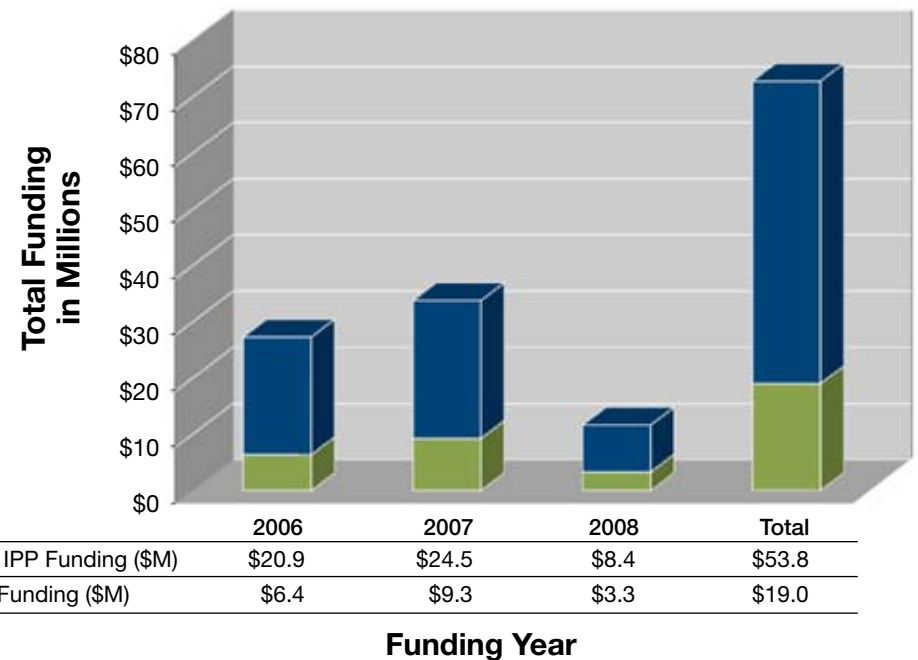
## Leveraging Funding from Partners

The IPP Seed Fund seeks to fund highly leveraged partnerships where all parties in each project share the costs, risks, benefits, and outcomes.

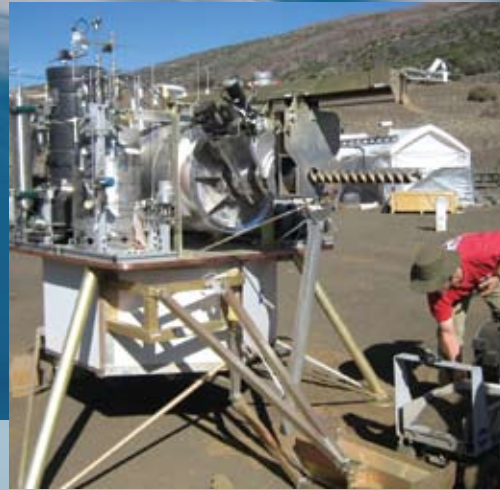
Over the past three years of this program, an aggregate IPP Seed Fund of \$19 million was combined with \$53.8 million of other non-IPP funding, for the advancement of critical technologies and capabilities.

The significant role of the IPP Seed Fund as a contributor to NASA's total R&D funds has been demonstrated over the past three years.

*The IPP Seed Fund Helps Expand NASA R&D Funds*



*for less*



Prototype lunar oxygen production system



Prototype robotic lunar resources prospector



Checking the condenser subsystem on the NASA oxygen production system

## Success story

### ***Lunar Analog Field Demonstration of ISRU & HRS Systems (KSC 2007)***

NASA's Kennedy Space Center (KSC) partnered with NASA's Johnson Space Center, NASA's Glenn Research Center, and Hawaii's Pacific International Space Center for Exploration Systems (PISCES) for a field demonstration of In Situ Resource Utilization (ISRU) and Human-Robotic Systems (HRS) in a location simulating a lunar environment. With additional contributions from the Canadian Space Agency, this project facilitated development of a test site to be used to assess anticipated system performance and operations. The State and PISCES plan to continue development of such sites and provide testing services to a variety of customers, promoting local economic growth.

From \$400K in IPP Seed funding, the total project funding from all partners reached \$2.8 million. This demonstrates an impressive leveraging of R&D dollars attributable to Seed Fund collaborations.

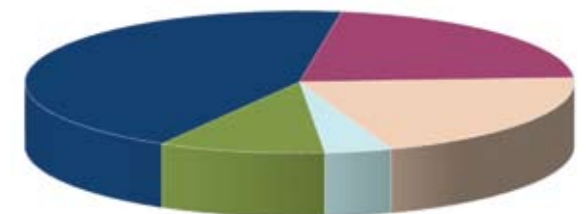
*This project featured other government agency and international partner involvement as well as promotion of Hawaii's economic growth.*



# Partners



*A Broad Spectrum of Partnering Success*



- Large Business (45)
- Small Business (22)
- University (21)
- FFRDC (4)
- Other Government Agency (10)

## Across the Continent

During the past three years, over 100 external partners from a wide circle of corporations, institutions, laboratories, and agencies have worked with NASA centers through the IPP Seed Fund.

These partners are located in 34 U.S. states and Ontario, Canada.



*IPP Encourages Widespread Partnerships*

## Engaging All Types of Partners

The IPP Seed Fund seeks cost-shared partnerships from a broad spectrum of sources, including industry, academia, research institutions, national laboratories, and other government agencies, for joint development of technology that is of primary interest to NASA.



## Success story

### ***Technologies for Cabin Noise Reduction (LaRC 2006)***

NASA's Langley Research Center (LaRC) joined forces with Gulfstream Aerospace, Boeing Commercial Airplanes, Polyumac Techno Core, and Purdue University to improve technology for cabin noise reduction, primarily for civil aviation applications but with potential application for space launch vehicles and habitats.

The diverse partnership enabled the project team to address two issues. The first was to better define boundary layer loads as a source of interior noise. The second was to provide an improved model of acoustic foams, allowing increased noise reductions to be integrated into the fabrication process. This second innovation will have potential impact in automotive and building applications.

*One IPP Seed Fund project*

*Four non-NASA partners*

*Large business, small business,  
and university partners*

*Technology impacts for NASA  
and commercial applications*

*Air Force Research Laboratory*

**Federal Aviation Administration**

**National Science Foundation**

State of Hawaii

*Space Florida*

**DARPA**

# **Other Government Agency** coordination

## **Maximizing Return On Investment**

In addition to working with commercial entities, the IPP Seed Fund also seeks to establish partnerships between NASA and other government agencies. These cooperative efforts improve the efficiency with which taxpayer dollars can be used for technology development across multiple agencies—the Federal Aviation Administration, the National Science Foundation, the Defense Advanced Research Projects Agency, military research laboratories, state agencies, and many others.

*Leveraging  
taxpayer dollars*







upper left: *Inflatable Habitat at McMurdo*

upper right: *Inside the Habitat*



center: *Habitat Data Center*

bottom: *External view during Antarctic winter (photo taken by remote camera)*

### ***Inflatable Habitat Field Demonstration (JSC 2006)***

NASA's Johnson Space Center (JSC) partnered with the National Science Foundation (NSF) and ILC Dover to fabricate and test a remotely deployed inflatable habitat in an extreme environment. The habitat was successfully deployed at McMurdo Station, Antarctica in less than 50 minutes, surviving 250 days of successful operation in the frigid Antarctic winter, with recorded temperatures as low as  $-75$  degrees F and winds gusting to 50 knots. The habitat packs like a tent, but inflates into a building. NSF is also considering whether the habitat may also be useful for Arctic research.

Technologies and capabilities developed by this project will be critical to future NASA space missions and to NSF's support of polar research here on Earth.

***Collaboration with  
ILC Dover and the National  
Science Foundation***

# Impacting Life Here and

# Terrestrial applications



K10 Red Acquiring Lidar Measurements

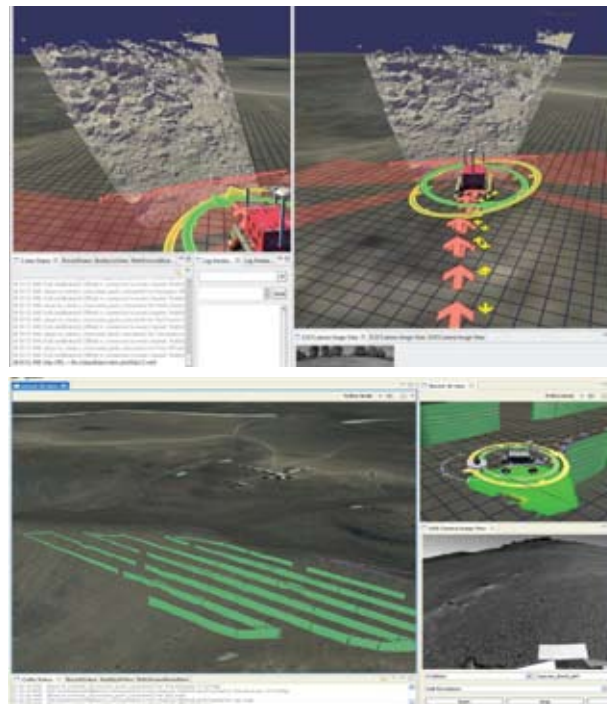
## Spinning Technology Out

Since its founding in 1958, NASA has dedicated itself to transferring space program advancements to Earth-based applications.

The innovative partnerships from the IPP Seed Fund support this goal by enhancing economic development through collaborations with industry, using their technologies for NASA missions, and facilitating the later spin-off of the resulting new technologies.

## Success story

### *Sensor Suites and Rover Systems for Surface Prospecting (ARC 2006)*



The NASA Ames Research Center's (ARC) Intelligent Robotics Group (IRG) is dedicated to enabling humans and robots to explore and learn about extreme environments, remote locations, and uncharted worlds. ARC partnered with the NASA Jet Propulsion Laboratory (JPL) and Ball Aerospace to increase NASA mission performance by off-loading tedious, repetitive tasks to robots.

In summer 2007, the project team field-tested a robotic survey system at Haughton Crater (Devon Island, Canada). Two NASA Ames K10 planetary rovers performed systematic surveys of several simulated lunar sites. This testing proved the robotic survey system to be suitable for both future planetary surface missions and terrestrial use.



# NASA's Work Beyond

## Infusion

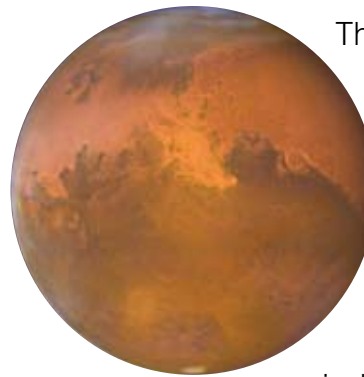
### Serving NASA Missions Through Infusion

IPP investments aim to complement Mission Directorate and Field Center efforts, filling important gaps in NASA's technology portfolio.

The IPP Seed Fund projects are furthering development of technology for infusion into missions. Potential for both time and cost savings become possible by leveraging technology already in development. Primarily, this involves dual-use partnerships, whereby both NASA and the external partner(s) from industry, academia, or government benefit from the R&D.

### Success story

#### *Joint Hardware-in-the-Loop (HWIL) Controllable Solid Propulsion Landing System Demonstration (JPL 2006)*



The NASA Jet Propulsion Laboratory (JPL) partnered with Alliant Techsystems (ATK) to develop a controllable solid motor for future planetary landings with 40 percent mass, 50 percent cost, and 50 percent volume reductions from a comparable liquid system.

Data from hot fire testing and simulations indicated that the solid propulsion landing system followed a realistic descent and would result in a successful landing.

The project team is working in collaboration with the Mars Science Laboratory (MSL) project to infuse this technology into future missions.



# IPP Seed Fund List of Partners 2006, 2007, 2008

## Aeronautics Research Mission Directorate (ARMD)

Alternative Fuels for Next Generation Combustor Applications (**GRC**)  
*Pratt & Whitney • AFRL*

Development and Investigation of the First Stage of a Highly Reliable Reusable Launch System (**DFRC**)  
*General Atomics • Embry-Riddle University • Holloman Air Force Base • Navy Philadelphia*

Electronic Prognostics for Critical Avionics Systems (**ARC**)  
*Impact Technologies*

Four-Dimensional Flight Management to Support the Next Generation Air Transportation System (NGATS) (**LaRC, ARC**)  
*Smiths Aerospace • Federal Aviation Administration*

Technologies for Cabin Noise Reduction (**LaRC**)  
*Gulfstream Aerospace • Boeing Commercial Airplanes • Polyumac Techno Core • Purdue University*

Advanced Thermal Protection Systems for Hypersonic Flight in Air and Planetary Atmospheres (**ARC**)  
*Touchstone Research Laboratory, Ltd.*

Carbon Nanotube Yarn Multifunctional Sensors in Composite Structures (**LaRC**)  
*3TEX, Inc. • University of Texas at Dallas*

Demonstration of Polymer Cross-Linked Aerogel Blanket Insulation (**GRC**)  
*Aspen Aerogels • Parker-Hannifin*

Development and Validation of Foam-Metal Acoustic Liner for Attenuation of Turbofan Engine Noise (**GRC, LaRC**)  
*Williams International • Hawker Beechcraft Corporation*

Distributed Aerodynamic Sensing and Processing (DASP) Toolbox (**DFRC**)  
*Tao Systems*

Low-Density Turbine Blade Superalloys for Improved Engine Performance and Reduced Emissions (**GRC**)  
*Honeywell Aerospace*

Multifunctional Nanocomposites for Aerospace Applications (**LaRC**)  
*Vorbeck Materials • Princeton University*

Health Monitoring of Aerospace Structures (**DFRC**)  
*University of Michigan*

## Exploration Systems Mission Directorate (ESMD)

Aero Performance Testing of High-Mach Decelerators and Materials Development for Inflatable Aeroshells (**LaRC**)  
*ILC Dover • Georgia Institute of Technology • ATK*

Cryo-Tracker® Mass Gauging System Hardware and Flight Qualification Risk Reduction (**KSC**)  
*Sierra Lobo, Inc.*

Exploration/National Science Foundation (NSF) Habitat Field Demonstration (**JSC**)  
*ILC Dover • NSF*

Fiber Reinforced Urethane Foam Development (**MSFC**)  
*DuPont*

Infusing Environmental Knowledge into Decision Support and Planning Tools for Exploration Mission Operations (**GSFC**)  
*United Space Alliance*

Integrating Sensor Suites and Rover Systems for Surface Prospecting: Enabling ISRU by Human-Robot Teams (**ARC, JPL**)  
*Ball Aerospace*

Multi-Terrain Loader for Lunar Surface Requirements Development (**JSC**)  
*Caterpillar*

New Lithium-ion Batteries with Enhanced Safety and Power Density for Future NASA and Aerospace Missions (**GRC, JPL, JSC**)  
*A123Systems • ABSL Space Products • Northrop Grumman*

PWR—Test-Stand and J2X Engine End-to-End Integrated System Health Management (ISHM) Capability (**SSC, ARC**)  
*Pratt & Whitney*

Space Radiation Analysis Tool (**LaRC**)  
*Los Alamos National Laboratory • University of Florida*





Validation of Cryogenic Composite Over-Wrapped Pressure Vessels and All-Composite Cryogenic Tanks (**MSFC, JPL**)  
*Orion Propulsion*

Addition of Electrodynamic & Mechanical Forces to Dem Software (**KSC, GRC**)  
*DEM Solutions*

Advanced Deep Throttling Turbine Bypass Valve (**MSFC**)  
*VACCO Industries • Dynamic Structures and Materials*

Advanced High-Pressure Electrolysis System Development for NASA's Explorations Systems Program (**JPL, GRC, JSC**)  
*Hamilton Sundstrand*

Cold Hardware Ignition Demonstration of Liquid Oxygen-Liquid Methane for Reaction Control and Main Propulsion Engines (**JSC, GRC, MSFC**)  
*WASK Engineering*

Development of a Deployable Sun Shield to Support Long Duration In-Space Cryogenic Propellant Storage (**KSC**)  
*United Launch Alliance • ILC Dover*

Extremely High-Performance, Ultra-Low Power, Radiation-Tolerant Processor: An Enabling Technology for Autonomous and Computationally Intensive Capabilities (**GSFC, JPL**)  
*Coherent Logix*

Flight Demonstration of a Lander Using Lox/Methane (**JSC, GRC, MSFC**)  
*Armadillo Aerospace*

Generalizing Moon Tire Technology (**GRC**)  
*Goodyear Tire and Rubber Company*

High Temperature Materials for Lunar Lander Engine (**MSFC**)  
*Pratt & Whitney • ATK*

Human-Rated Space Power Systems Pallet Demonstrating Fuel Cells, Lithium-Ion Batteries and Advanced Thermal Management Technologies (**GRC**)  
*Boeing • Teledyne Energy Systems*

Integrated Systems Health Management (ISHM) Implementation and Validation for A-1 Test Stand and J-2x Power Pack (**SSC**)  
*Pratt & Whitney*

Low-Temperature, Long-Life, Compliant Wheels for the Lunar Surface and Beyond (**JPL**)  
*Michelin Americas Research and Development Corp. • Clemson University • University of Hawaii at Hilo*

Lunar Analog Field Demonstration of ISRU & HRS (**KSC, JSC**)  
*University of Hawaii at Hilo • Canadian Space Agency • Office of Aerospace Development—Hawaii*

Lunar Regolith Excavation, Handling & Processing Technology Development & Demonstrations for Outpost Operations (**GRC**)  
*Northern Centre for Advanced Technology Inc. (NORCAT)*

Multi-Terrain Loader Remotely Supervised Leveling for Lunar Construction Development (**JSC, KSC**)  
*Caterpillar*

Safer Lithium-Ion Rechargeable Cells for Energy Storage (**JSC, GRC**)  
*Quallion, LLC*

Air Quality Management Using Photocatalytic Oxidation (**MSFC**)  
*Honeywell International*

Cryogenic Propellant Boil-off Reduction (**GRC**)  
*Ball Aerospace*

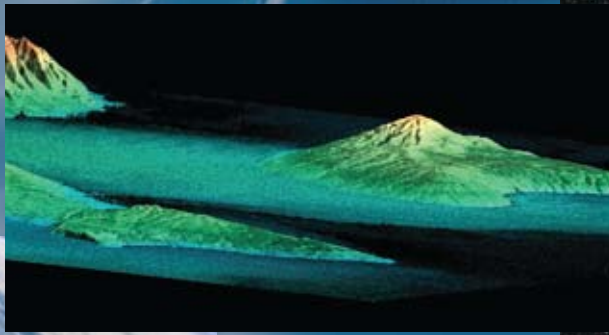
Dynamic Optical Filtration System for Vision System Protection (**JSC**)  
*Tietronix*

High Precision Inertial Measurement System (**LaRC**)  
*Sigenics Inc. • High Chiva Systems Inc. • International Photonics*

Surface Inflatable Module Joining Demonstration (**JSC**)  
*ILC Dover • Boeing*

## **Science Mission Directorate (SMD)**

Concept Study for the Application of Phase Diversity-Only Adaptive/Lightweight Optics to NASA Science Missions (**ARC**)  
*General Dynamics*



Development of a Continuous ADR and Integrated Control Electronics (**GSFC**)  
*Lake Shore Cryotronics • Lockheed Martin*

High Performance Amplifiers for Science Instruments (**JPL**)  
*Northrop Grumman*

Joint Hardware in the Loop Solid Propulsion Landing System Demonstration (**JPL**)  
*Alliant Techsystems*

Large Focal Plane Technology for Simultaneous Imaging and Guiding (**GSFC**)  
*Lockheed Martin • Teledyne (TIS) • Conceptual Analytics • US Naval Observatory • Rochester Institute of Technology • Lawrence Berkeley National Lab/SNAP Collaboration • University of Hawaii*

Lightweight, Cryostable, Low-Cost Mirrors for the Next Generation of Space Telescopes (**GSFC, MSFC**)  
*ITT Space Systems*

Real-Time Multi-Mission Autonomous Onboard GN&C Instrument (**JPL**)  
*Draper Laboratory*

Remote Sensing of Temperature and Pressure for Improved Retrievals of Atmospheric Constituents (**LaRC**)  
*ITT Corp. • University of New Hampshire*

Two-Micron Risk Reduction Laser Transmitter for Airborne and Space-Based Doppler Wind Lidar (**LaRC**)  
*Fibertek, Inc*

Demonstration of a Phase Induced Amplitude Apodization Coronagraph in a Very High Contrast Imaging Testbed (**ARC**)  
*Subaru Telescope • Lockheed Martin*

Demonstration of Precise Wavefront Control for Space Optics with a MEMS Deformable Mirror (**ARC**)  
*Subaru Telescope • Lockheed Martin*

Helium Superpressure Balloon Technology Validation Experiments (**JPL**)  
*Near Space Corporation*

Ice-Ax: ISRU Characterization Experiment—Astrobiology Explorer (**ARC**)  
*Boeing • Alliance Space Systems • Cooper Consulting • University of California—Berkeley • University of Kentucky Research Foundation • Los Alamos National Laboratory*

Mission Enabling, Lightweight, Ultra Bandwidth Inverse Synthetic Aperture Radar (Isar) for Characterization of the Interior of Planetary Bodies (**GSFC**)  
*Penetradar Corporation • Applied EM • The Ohio State University*

Replacing Multiple Fiber Amplifiers with One for Mapping Lidars Featuring Multiple Frequency-Doubled Beams (**GSFC**)  
*Fibertek, Inc.*

Risk Reduction Testing of the Astromesh Reflector in Support of Earth Science Missions (**JPL**)  
*Northrop Grumman*

Small-Sat Technologies for Cost Effective Hyperspectral Remote Sensing of the Environment (**ARC**)  
*Northrop Grumman • Utah State University*

Spacewire Plug-and-Play Capable GPS Receiver (**GSFC**)  
*AFRL/VSSE*

Advanced Microwave System Architecture Demo (**GSFC**)  
*Northrop Grumman*

Advances In Photometric Precision for All Sky Exoplanet Surveys (**ARC**)  
*Google, Inc. • MIT*

Enabling Suborbital Science Persistence, a Global Hawk-Instrument Incubator Program Technology Transition Project (**LaRC**)  
*Northrop Grumman • ITT Corp*

Facilitating Climate Modeling Research by Integrating NASA and the Earth System Grid (**JPL**)  
*Lawrence Livermore National Laboratory*

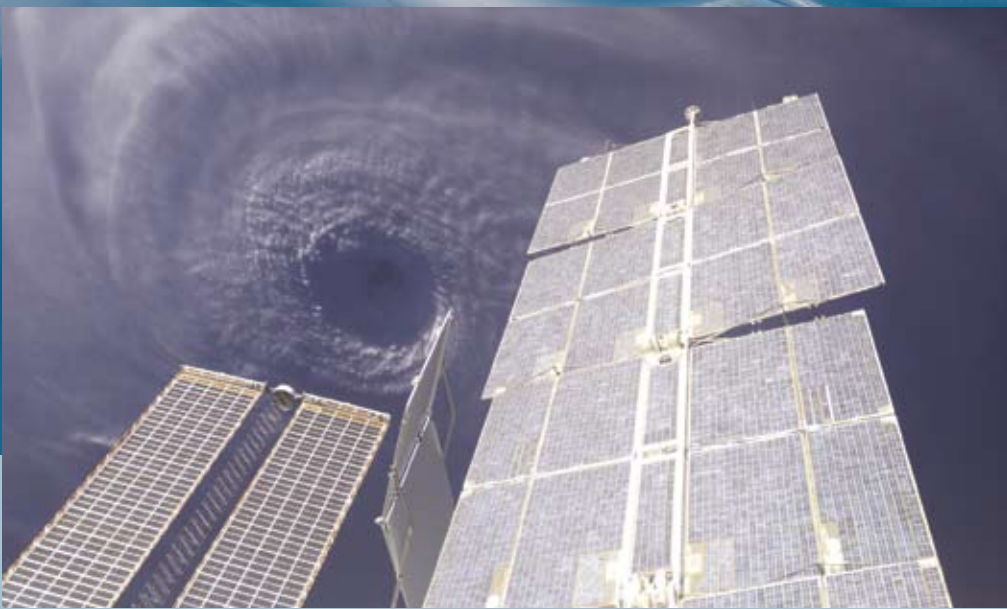
FASTRACK Flight Testing, Safety Certification, & Enhancement (**KSC**)  
*Zero G Corp. • Space Florida*

High-Endurance Hall Thruster for Deep Space Science Missions—Subject to Export Control (**GRC**)  
*Busek*

## Space Operations Mission Directorate (SOMD)

Ground Operations Health Management (GOHM)—A Framework for Intelligent Integration of Technologies (**SSC, KSC**)  
*ASRC Aerospace • Penn State University*





Portable Test Stand System

## Success story

GA-ISHM Root Cause Analysis Expansion Program—Intelligent Integrated System Health Management (I2SHM) (**SSC**)  
*General Atomics*

Lunar Communication and Navigation Satellite Network Architecture—Internet Protocol, Lasers and Small Satellites (**ARC, JPL**)  
*Ball Aerospace • Cisco Systems*

Self-Healing Wire Insulation—Preventing Wiring Failures (**KSC**)  
*ASRC Aerospace*

Development and Rapid Assessment of a Smart, Environmentally Friendly Coating (**KSC**)  
*PPG Industries • University of Texas Health Science Center*

Glass Bubble Insulation for Cryogenic Tanks: A Field Demonstration (**SSC, KSC**)  
*3M Energy and Advanced Materials Division • Technology Applications, Inc.*

Innovative Treatments of Dental Emergencies for Lunar and Exploration Missions (**JSC**)  
*BioMat Sciences*

Integrating Space Weather Model and Event Data into Decision Support Systems to Ensure Exploration Safety and Mission Success (**GSFC, JSC**)  
*United Space Alliance*

Liquid to Gaseous Helium Pump Skid (**KSC**)  
*Sierra Lobo, Inc.*

Lunar Habitat Wireless Testbed (**JSC, GRC, JPL**)  
*UC-Boulder Aerospace*

Autonomous Flight Safety System (**GSFC, KSC**)  
*DARPA*

Evolved Antenna Technology (**ARC**)  
*JEM Engineering • Carnegie Mellon University*

Intelligent Valves for Integrated System Health Management (ISHM) (**SSC**)  
*Rowan University*

## Root Cause Analysis Expansion Program for ISHM (SSC 2006)

Integrated System Health Management (ISHM) helps to improve safety, affordability, and reliability of the complex systems developed to meet NASA's mission objectives, including the Space Shuttle, International Space Station, and the Constellation Program. NASA's Stennis Space Center (SSC) partnered with General Atomics (GA) to improve the anomaly detection and root cause analysis components of ISHM. These improvements were successfully demonstrated with the Methane Thruster Test Bed (MTTP) and an A1 Rocket Engine Test Stand (RETS).

NASA plans to infuse these advancements into existing and future projects. In addition, GA is using the enhanced capabilities for company-wide projects, including several for the U.S. Navy.



*Pratt & Whitney Geared Turbofan Engine*

*For more information about NASA's  
Innovative Partnerships Program, please visit*

*<http://ipp.nasa.gov>*

## Success story

### ***Alternative Fuels for Next Generation Combustor Applications (GRC 2006)***

NASA's Glenn Research Center (GRC) partnered with Pratt & Whitney (P&W) and the Air Force Research Laboratory (AFRL) at Wright Patterson Air Force Base to assess alternative fuels for commercial aircraft engines. The project team evaluated the potential impact on performance improvement and emission reductions using current combustors built by P&W.

The team was able to successfully run the engines with various fuel blends, including pure alternative fuel, and to achieve reduced particulate matter compared with conventional jet fuel with no observed adverse impact on the combustor.

GRC and P&W plan additional collaborations to continue this work with AFRL as well as with commercial partners. These collaborations may result in more environmentally-friendly commercial aircraft operations here on Earth.